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AGREEMENT

CONCERNING THE ADOPTION OF UNIFORM CONDITIONS OF APPROVAL AND RECIPROCAL RECOGNITION OF APPROVAL FOR MOTOR VEHICLE EQUIPMENT AND PARTS

done at Geneva on 20 March 1958

Addendum 48: Regulation No. 49

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UNIFORM PROVISIONS CONCERNING THE APPROVAL OF COMPRESSION IGNITION (C.I.) ENGINES AND VEHICLES EQUIPPED WITH C.I. ENGINES WITH REGARD TO THE EMISSIONS OF GASEOUS POLLUTANTS BY THE ENGINE

UNITED NATIONS

Regulation No.49

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF COMPRESSION IGNITION (C.I.) ENGINES AND VEHICLES EQUIPPED WITH C.I. ENGINES WITH REGARD TO THE EMISSIONS OF GASEOUS POLLUTANTS BY THE ENGINE

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Regulation No.49

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF COMPRESSION IGNITION (C.I.) ENGINES AND VEHICLES EQUIPPED WITH C.I. ENGINES WITH REGARD TO THE EMISSIONS OF GASEOUS POLLUTANTS BY THE ENGINE

1. SCOPE

This Regulation applies to the emission of gaseous pollutants from C.I. engines used for driving motor vehicles having a design speed exceeding 25 km/h of categories 1/ 2/ M_1 having a total mass exceeding 3.5 tonnes. M_2, M_3, N_1, N_2 and N_3.

2. DEFINITIONS AND ABBREVIATIONS

For the purposes of this Regulation,

2.1. "Approval of a vehicle" means the approval of a vehicle type with regard to the level of the emission of gaseous pollutants by the engine;

2.2. "Approval of an engine" means the approval of an engine type with regard to the level of the emission of gaseous pollutants;

2.3. "Compression ignition (C.I.) engine" means an engine which works on the compression-ignition principle (e.g. diesel engine);

2.4. "Engine type" means a category of engines which do not differ in such essential respects as engine characteristics as defined in annex 1 to this Regulation;

2.5. "Vehicle type" means a category of vehicles which do not differ in such essential respects as engine and vehicle characteristics as defined in annex 1 to this Regulation;

2.6. "Gaseous pollutants" means carbon monoxide, hydrocarbons (assuming a ratio of $C_1H_{1,85}$) and oxides of nitrogen, the last named being expressed in nitrogen dioxide (NO_2) equivalent;

2.7. "Net power" means the power in "ECE kW" obtained on the test bench at the end of the crankshaft, or its equivalent, measured in accordance with the ECE method of measuring the power of internal combustion engines for road vehicles; 3/

1/ In conformity with consolidated resolution R.E.3 (TRANS/SC1/WP29/78).

2/ C.I. engines used by category N_1 and N_2 and M_2 power-driven vehicles are not approved according to this Regulation, provided that such vehicles are approved according to Regulation No.83.

3/ As described in Regulation No.85.

2.8. "Rated speed" means the maximum full load speed allowed by the governor as specified by the manufacturer in his sales and service literature;

2.9. "Per cent load" means the fraction of the maximum available torque at an engine speed;

2.10. "Maximum torque speed" means the engine speed at which the maximum torque is obtained from the engine, as specified by the manufacturer;

2.11. "Intermediate speed" means the speed corresponding to the maximum torque value if such speed is within the range of 60 to 75% of rated speed: in other cases it means a speed equal to 60% of rated speed;

2.12. Abbreviations and units

P	kW	net power output, non-corrected
$\overline{CO}$	g/kWh	carbon monoxide emission
$\overline{HC}$	g/kWh	hydrocarbon emission
$\overline{NO_x}$	g/kWh	emission of oxides of nitrogen
conc	ppm	concentration (ppm by volume)
mass	g/h	pollutant mass flow rate
G''_{EXH}	kg/h	exhaust gas mass flow rate on wet basis
V'_{EXH}	m^3/h	exhaust gas volume flow rate on dry basis calculated at 101.3 kPa and 273 K
V''_{EXH}	m^3/h	exhaust gas volume flow rate on wet basis calculated at 101.3 kPa and 273 K
G''_{AIR}	kg/h	intake air mass flow rate on wet basis
V''_{AIR}	m^3/h	intake air volume flow rate on wet basis
G_{FUEL}	kg/h	fuel mass flow rate
WF		weighting factor
HFID		heated flame ionization detector
NDIR		non-dispersive infra-red
HCLA		heated chemiluminescent analyser.

3. APPLICATION FOR APPROVAL

3.1. Application for approval of an engine as a separate technical unit

3.1.1. The application for approval of an engine with regard to the level of the emission of gaseous pollutants shall be submitted by the engine manufacturer or by a duly accredited representative.

3.1.2. It shall be accompanied by the undermentioned documents in triplicate and the following particulars:

A description of the engine type comprising the particulars referred to in annex 1 to this Regulation.

3.1.3. An engine conforming to the "engine type" characteristics described in annex 1 shall be submitted to the technical service responsible for conducting the approval tests defined in paragraph 5.

3.2. Application for approval of a vehicle in respect of its engine

3.2.1. The application for approval of a vehicle with regard to emission of gaseous pollutants by its engine shall be submitted by the vehicle manufacturer or a duly accredited representative.

3.2.2. It shall be accompanied by the undermentioned documents in triplicate and the following particulars:

A description of the engine type and of engine-related vehicle parts comprising the particulars referred to in annex 1, as applicable, and a copy of the ECE Type-Approval Communication document (annex 2A) for the engine as a separate technical unit which is installed in the vehicle type.

3.3. Arrangements for control of conformity of production

3.3.1. The competent authority shall verify the existence of satisfactory arrangements for ensuring effective control of the conformity of production before type approval is granted.

4. APPROVAL

4.1. If the engine or the vehicle submitted for approval pursuant to paragraphs 3.1 or 3.2 of this Regulation meets the requirements of paragraphs 5 and 6 below, approval of that type of engine or the vehicle shall be granted.

4.2. An approval number shall be assigned to each type approved. Its first two digits (at present 01 corresponding the 01 series of amendments which entered into force on 14 May 1990) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same number to another engine type or vehicle type.

4.3. Notice of approval or of extension or refusal of approval of an engine type or vehicle type pursuant to this Regulation shall be communicated to the Parties to the 1958 Agreement which apply this Regulation, by means of a form conforming to the model in annex 2A or 2B, as applicable, to this Regulation. Values measured during the type test shall also be shown.

4.4. There shall be affixed, conspicuously and in a readily accessible place to every engine conforming to an engine type approved under this Regulation, or to every vehicle conforming to a vehicle type approved under this Regulation, an international approval mark consisting of:

4.4.1. a circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval; 4/

4.4.2. the number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in paragraph 4.4.1.

4.5. If the vehicle or engine conforms to an approved type under one or more other Regulations annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 4.4.1 need not be repeated; in such a case, the regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 4.4.1.

4/ 1 for the Federal Republic of Germany, 2 for France, 3 for Italy, 4 for The Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech and Slovak Federal Republic, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 for the German Democratic Republic, 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal and 22 for the Union of Soviet Socialist Republics. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

4.6. The approval mark shall be placed close to or on the data plate affixed by the manufacturer to the approved type.

4.7. Annex 3 to this Regulation gives examples of arrangements of approval marks.

4.8. The engine approved as a technical unit must bear, in addition to the approved mark:

4.8.1. the trademark or trade name of the manufacturer of the engine;

4.8.2. the manufacturer's commercial description.

4.9. These marks must be clearly legible and indelible.

5. SPECIFICATIONS AND TESTS

5.1. General

The components liable to affect the emission of gaseous pollutants shall be so designed, constructed and assembled as to enable the engine, in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.

5.2. Specifications concerning the emission of pollutants

The emission of pollutants by the engine submitted for testing shall be measured by the method described in annex 4. Other methods may be approved if it is found that they yield equivalent results. The emissions of the carbon monoxide, the emissions of the hydrocarbons and the emissions of the oxides of nitrogen obtained shall not exceed the amounts shown in the table below:

Mass of carbon monoxide (CO) grammes per kWh	Mass of hydro-carbons (HC) grammes per kWh	Mass of oxides of nitrogen (NO_x) grammes per kWh
11.2	2.4	14.4

6. INSTALLATION ON THE VEHICLE

6.1. The engine installation on the vehicle shall comply with the following characteristics in respect to the type-approval of the engine.

6.1.1. Intake depression shall not exceed that specified for the type-approved engine in annex 2A.

6.1.2. Exhaust back pressure shall not exceed that specified for the type-approved engine in annex 2A.

6.1.3. Maximum power absorbed by the engine-driven equipment shall not exceed the maximum permissible power specified for the type approved engine in annex 2A.

7. CONFORMITY OF PRODUCTION

7.1. Every engine or vehicle bearing an approval mark as prescribed under this Regulation shall be so manufactured as to conform, with regard to the description as given in the approval form and its annexes, to the approved type.

7.2. In order to verify that the requirements of paragraph 7.1 are met, suitable controls of the production shall be carried out.

7.3. The holder of the approval shall in particular:

7.3.1. ensure existence of procedures for the effective control of the quality of the product;

7.3.2. have access to the control equipment necessary for checking the conformity to each approved type;

7.3.3. ensure that data of test results are recorded and that annexed documents shall remain available for a period to be determined in accordance with the administrative service;

7.3.4. analyse the results of each type of test, in order to verify and ensure the stability of the engine characteristics, making allowance for variations in the industrial production process;

7.3.5. ensure that any sampling of engines or components giving evidence of non-conformity with the type of test considered shall give rise to another sampling and another test. All the necessary steps shall be taken to re-establish the conformity of the corresponding production.

7.4. The competent authority which has granted type-approval may at any time verify the conformity control methods applicable to each production unit.

7.4.1. In every inspection, the test books and production survey records shall be presented to the visiting inspector.

7.4.2. When the quality level appears unsatisfactory or when it seems necessary to verify the validity of the data presented in application of paragraph 7.4.1., the following procedure is adopted:

7.4.2.1. An engine is taken from the series and subjected to the test described in annex 4. The emissions of the carbon monoxide, the emissions of the hydrocarbons and the emissions of the oxides of nitrogen obtained shall not exceed the amounts shown in the table below:

Mass of carbon monoxide (CO) grammes per kWh	Mass of hydro-carbons (HC) grammes per kWh	Mass of oxides of nitrogen (NO_x) grammes per kWh
12.3	2.6	15.8

7.4.2.2. If the engine taken from the series does not satisfy the requirements of paragraph 7.4.2.1 the manufacturer may ask for measurements to be performed on a sample of engines taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean $\bar{x}$ of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to conform if the following condition is met:

$$\bar{x} + k.S \leq L \quad 5/$$

where:

L is the limit value laid down in paragraph 7.4.2.1 for each gaseous pollutant considered; and

k is a statistical factor depending on n and given in the following table:

n	2	3	4	5	6	7	8	9	10
k	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279
n	11	12	13	14	15	16	17	18	19
k	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

if $n \geq 20$ $\quad k = \frac{0.860}{\sqrt{n}}$

5/ $S^2 = \frac{\Sigma (x - \bar{x})^2}{n - 1}$ where x is any one of the individual results obtained with the sample n.

7.4.3. The technical service responsible for verifying the conformity of production shall carry out tests on engines which have been run-in partially or completely, according to the manufacturer's specifications.

7.4.4. The normal frequency of inspections authorized by the competent authority shall be 1 per year. If the requirements of paragraph 7.4.2 are not met, the competent authority shall ensure that all necessary steps are taken to re-establish the conformity of production as rapidly as possible.

8. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

8.1. The approval granted in respect of an engine type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 7.1 are not complied with or if the engine or engines taken fail to pass the tests prescribed in paragraph 7.4.

8.2. If a Contracting Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation by means of a communication form conforming to the model in annexes 2A or 2B to this Regulation.

9. MODIFICATION AND EXTENSION OF APPROVAL OF THE APPROVED TYPE

9.1. Every modification of the approved type shall be notified to the administrative department which approved the type. The department may then either:

9.1.1. Consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the modified type still complies with the requirement: or

9.1.2. Require a further test report from the technical service conducting the tests.

9.2. Confirmation or refusal of approval, specifying the alterations, shall be communicated by the procedure specified in paragraph 4.3 to the Parties to the Agreement applying this Regulation.

9.3. The competent authority issuing the extension of approval, shall assign a series number for such an extension and inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in annexes 2A or 2B to this Regulation.

10. PRODUCTION DEFINITELY DISCONTINUED

If the holder of the approval completely ceases to manufacture the type approved in accordance with this Regulation he shall so inform the authority which granted the approval. Upon receiving the relevant communication that authority shall inform thereof the other Parties to the Agreement which apply this Regulation by means of a communication form conforming to the model in annexes 2A or 2B to this Regulation.

11. TRANSITORY PROVISIONS

11.1. From the date of entry into force of this 01 series of amendments, Parties to the Agreement may no longer issue approvals to the original unamended version of this Regulation.

11.2. One year after the date of entry into force of this 01 series of amendments, approvals granted under the original unamended version of this Regulation shall cease to be valid.

11.3. Approvals granted under the original unamended version of this Regulation shall, at the request of the manufacturer, be updated to this Regulation provided the requirements of paragraph 5 of this Regulation were met at the time the original approval was granted.

12. NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the 1958 Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries are to be sent.

Annex 1

ESSENTIAL CHARACTERISTICS OF THE ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TEST

1. Description of Engine

1.1. Manufacturer: .....

1.2. Manufacturer's engine code: .....

1.3. Cycle: four stroke/two stroke 1/

1.4. Bore: .....mm

1.5. Stroke: .....mm

1.6. Number and layout of cylinders: .....

1.7. Engine capacity: .....cm^3

1.8. Rated Speed: .....

1.9. Maximum Torque Speed: .....

1.10. Volumetric compression ratio: 2/ .....

1.11. Combustion system description: .....

1.12. Drawing(s) of combustion chamber and piston crown

1.13. Minimum cross-sectional area of inlet and outlet ports: .....

1.14. Cooling system

1.14.1. Liquid

1.14.1.1. Nature of liquid: .....

1.14.1.2. Circulating pump(s): yes/no 1/

1.14.1.3. Characteristics or make(s) and type(s) (if applicable): .....

1.14.1.4. Drive ratio(s) (if applicable): .....

1.14.2. Air

1.14.2.1. Blower: yes/no 1/

1.14.2.2. Characteristics or make(s) and type(s) (if applicable): .....

1.14.2.3. Drive ratio(s) (if applicable): .....

1.15. Temperature permitted by the manufacturer

1.15.1. Liquid cooling: Maximum temperature at outlet: .....K

1.15.2. Air cooling: Reference point: .....

Maximum temperature at reference point: .....K

1/ Strike out what does not apply.

2/ Specify the tolerance.

1.15.3. Maximum charge air outlet temperature of the inlet intercooler (if applicable): .....K

1.15.4. Maximum exhaust temperature at the point in the exhaust pipe(s) adjacent to the outer flange(s) of the exhaust manifold(s): .....K

1.15.5. Fuel temperature: min ..... K. max .....K

1.15.6. Lubricant temperature: min ..... K. max .....K

1.16. Pressure charger: yes/no 1/

1.16.1. Make: .....

1.16.2. Type: .....

1.16.3. Description of the system (e.g. max. charge pressure, wastegate, if applicable): .....

1.16.4. Intercooler: yes/no 1/

1.17. Intake system: Maximum allowable intake depression at rated engine speed and at 100% load: .....kPa

1.18. Exhaust system: Maximum allowable exhaust back pressure at rated engine speed and at 100% load: .....kPa

2. Additional devices to reduce gaseous pollutants (if any, and if not covered by another heading)
Description and/or diagram(s): .....

3. Fuel feed

3.1. Feed pump
Pressure 2/: .....kPa or characteristics diagram 2/: .....

3.2. Injection system

3.2.1. Pump

3.2.1.1. Make(s): .....

3.2.1.2. Type(s): .....

3.2.1.3. Delivery: .....mm^3 2/ per stroke or cycle at pump speed of: ..... rpm at full injection, or characteristic diagram 1/ 2/: .....
Mention the method used: On engine/on pump bench 1/

1/ Strike out what does not apply.

2/ Specify the tolerance.

3.2.1.4. Injection advance

3.2.1.4.1. Injection advance curve 1/: .....

3.2.1.4.2. Timing 1/: .....

3.2.2. Injection piping

3.2.2.1. Length: .....mm

3.2.2.2. Internal diameter: .....mm

3.2.3. Injector(s)

3.2.3.1. Make(s): .....

3.2.3.2. Type(s): .....

3.2.3.3. Opening pressure: .....kPa 1/

or characteristic diagram 1/ 2/

3.2.4. Governor

3.2.4.1. Make(s): .....

3.2.4.2. Type(s): .....

3.2.4.3. Speed at which cut-off starts under full load 1/: .....rpm

3.2.4.4. Maximum no-load speed 1/: .....rpm

3.2.4.5. Idling speed 1/: .....rpm

3.3. Cold Start System

3.3.1. Make(s): .....

3.3.2. Type(s): .....

3.3.3. Description: .....

4. Valve timing

4.1. Maximum lift of valves and angles of opening and closing in relation to dead centres or equivalent data: .....

4.2. Reference and/or setting ranges 2/

5. Engine-driven equipment

Maximum permissible power, declared by the manufacturer absorbed by the engine-driven equipment as specified in and under the operating conditions of Regulation No.85 regarding the measurement of the engine power, at the engine speeds defined in paragraphs 2.8 and 2.11 of the Definitions and Abbreviations to this Regulation.

Intermediate: .....kW, Rated: .....kW

6. Additional information on test conditions

6.1. Lubricant used: .....

1/ Specify the tolerance.
2/ Strike out what does not apply.

6.1.1. Make: .....

6.1.2. Type: .....

(State percentage of oil in mixture if lubricant and fuel are mixed)

6.2. Engine-driven equipment (if applicable)

6.2.1. Enumeration and identifying details: .....

6.2.2. Power absorbed at indicated engine speeds

(as specified by the manufacturer):

Equipment	Power absorbed (kW) at various engine speeds	
	Intermediate	Rated
Total		

6.3. Dynamometer setting (kW)

Per cent load	Dynamometer Setting (kW) at various engine speeds	
	Intermediate	Rated
10		
25		
50		
75		
100		

7. Engine performance

7.1. Engine speeds

Idle: .....rpm

Intermediate: .....rpm

Rated: .....rpm

7.2. Engine power 1/

Condition	Power (kW) at various engine speed	
	Intermediate	Rated
Maximum power measured on test kW (a)		
Total power absorbed by engine driven equipment as per point 6.2. kW (b)		
Gross engine power kW (c)		
Maximum permissible power absorbed as per point 5 kW (d)		
Minimum net engine power kW (e)		

$c = a + b$ and $e = c - d$

1/ Measured in accordance with the provisions of ECE Regulation No.85.

Appendix

CHARACTERISTICS OF THE ENGINE-RELATED VEHICLE PARTS (FOR TYPE APPROVAL OF A VEHCILE TYPE IN RESPECT OF ITS ENGINE)

1. Intake system depression at rated engine rpm and at 100% load 1/: .....kPa

2. Exhaust system back pressure at rated engine rpm and at 100% load 1/: .....kPa

3. Power absorbed by the engine-driven equipment as specified in and under the operation conditions of the ECE Regulation No.85 regarding the measurement of the engine power at the engine speeds defined in paragraphs 2.8 and 2.11 of the Definitions and Abbreviations to this Regulation.

Equipment	Power absorbed (kW) at engine speed	
	Intermediate	Rated
Total		

1/ To be within the limits specified in paragraphs 1.17 and 1.18 of annex 1.

Annex 2A

COMMUNICATION

(Maximum format: A4 (210 x 297 mm))

issued by: Name of administration

.....

.....

.....

concerning: 2/ APPROVAL GRANTED
APPROVAL EXTENDED
APPROVAL REFUSED
APPROVAL WITHDRAWN
PRODUCTION DEFINITELY DISCONTINUED

of a diesel engine type as a separate technical unit with regard to the emission of gaseous pollutants pursuant to Regulation No.49

Approval No. ... Extension No. ...

---

1. Trade name or mark of the engine: .....

2. Engine type: .....

3. Manufacturer's name and address: .....

4. If applicable, name and address of manufacturer's representative:

.....

5. Maximum allowable intake depression: .....kPa

6. Maximum allowable back pressure: .....kPa

7. Maximum permissible power absorbed by the engine-driven equipment:

Intermediate: .....kW; Rated: .....kW

8. Restrictions of use (if any):

9. Emission levels - 13 mode emission test values:

CO .....g/kWh; HC .....g/kWh; NO_x .....g/kWh

10. Engine submitted for tests on: .....

11. Technical service responsible for conducting the approval tests:

.....

12. Date of test report issued by that service: .....

13. Number of test report issued by that service: .....

14. Approval granted/refused/extended/withdrawn 2/ .....

15. Site of approval mark on the engine: .....

16. Place: .....

17. Date: .....

18. Signature: .....

19. The following documents, bearing the approval number shown above, are annexed to this communication:

One copy of annex 1 to this Regulation completed and with the drawings and diagrams referred to attached.

1/ Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).

2/ Strike out what does not apply.

Annex 2B

COMMUNICATION

(Maximum format: A4 (210 x 297 mm))

issued by: Name of administration

.....

.....

.....

concerning: 2/ APPROVAL GRANTED
APPROVAL EXTENDED
APPROVAL REFUSED
APPROVAL WITHDRAWN
PRODUCTION DEFINITELY DISCONTINUED

of a vehicle type with regard to the emission of gaseous pollutants by the engine pursuant to Regulation No.49

Approval No. ... Extension No. ...

---

1. Trade name or mark of the vehicle: .....

2. Vehicle type: .....

3. Manufacturer's name and address: .....

4. If applicable, name and address of manufacturer's representative:

.....

5. Maximum intake depression: .....kPa

6. Maximum back pressure: .....kPa

7. Maximum power absorbed by the engine-driven equipment:

Intermediate: .....kW; Rated: .....kW

8. Make and type of engine: .....

9. Emission levels:

9.1. 13 mode emission test values 2/:

CO .....g/kWh; HC .....g/kWh; NO_x .....g/kWh

9.2. Or, if the engine has been type approved as a separate technical unit 2/

9.2.1. Type-approval number of the engine: .....

9.2.2. Holder of the engine type approval: .....

10. Engine submitted for tests on: .....

11. Technical service responsible for conducting the approval tests:

.....

12. Date of test report issued by that service: .....

13. Number of test report issued by that service: .....

14. Approval granted/refused/extended/withdrawn 2/ .....

15. Site of approval mark on the vehicle/engine 2/ .....

16. Place: .....

17. Date: .....

18. Signature: .....

19. The following documents, bearing the approval number shown above, are annexed to this communication:

One copy of annex 1 to this Regulation completed and with the drawings and diagrams referred to attached.

1/ Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).

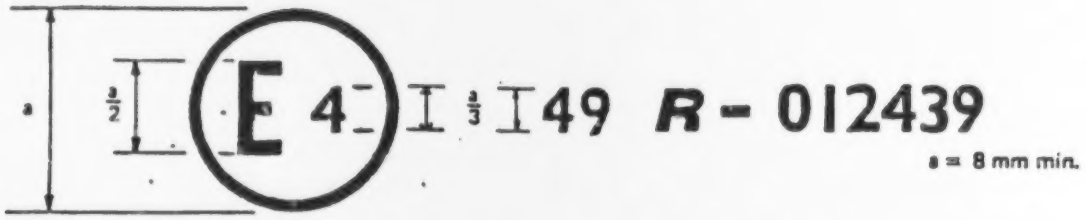
2/ Strike out what does not apply.

Annex 3

ARRANGEMENTS OF APPROVAL MARKS

Model A

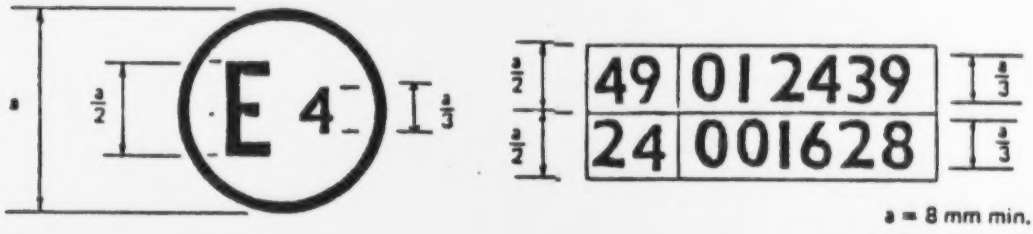
(See paragraph 4.4 of this Regulation)



The above approval mark affixed to an engine shows that the engine type concerned has been approved in the Netherlands (E4) pursuant to Regulation No.49 and under approval number 012439. The first two digits of the approval number indicate that Regulation No.49 already included the 01 series of amendments when the approval was granted.

Model B

(See paragraph 4.5 of this Regulation)



The above approval mark affixed to an engine shows that the engine type concerned has been approved in the Netherlands (E4) pursuant to Regulations Nos.49 and 24 1/. The first two digits of the approval numbers indicate that, at the dates when the respective approvals were granted, Regulation No.49 included the 01 series of amendments but Regulation No.24 was still in its original form.

1/ The latter number is given merely as an example.

Annex 4

TEST PROCEDURE

1. Introduction

1.1. This annex describes the method of determining emissions of gaseous pollutants from the engines to be tested.

1.2. The test shall be carried out with the engine mounted on a test bench and connected to a dynamometer.

2. Engine test conditions

2.1. The absolute temperature T of the engine air at the inlet to the engine expressed in Kelvin, and the dry atmospheric pressure ps, expressed in kPa, shall be measured, and the parameter F shall be determined according to the following provisions:

2.2. Naturally aspirated and mechanically supercharged engines:

$$F = \left[\frac{99}{ps} \right] \left[\frac{T}{298} \right]^{0.7}$$

2.3. Turbo-charged engine with or without cooling of inlet air:

$$F = \left[\frac{99}{ps} \right]^{0.7} \left[\frac{T}{298} \right]^{1.5}$$

2.4. For a test to be recognized as valid, the parameter F shall be such that;

$$0.96 \leq F \leq 1.06$$

3. Fuel

The fuel shall be the reference fuel specified in annex 5.

4. Test Cycle

4.1. The following 13-mode cycle shall be followed in dynamometer operation on the test engine:

Mode No	Engine Speed	Per cent load
1	idle	-
2	intermediate	10
3	"	25
4	"	50
5	"	75
6	"	100
7	idle	-
8	rated	100
9	"	75
10	"	50
11	"	25
12	"	10
13	idle	-

4.2. Test run

During each mode of the test cycle the specified speed shall be held to within ± 50 rpm and the specified torque shall be held within ± 5% of the maximum torque at the test speed. The fuel temperature at the injection pump inlet shall be 306K - 316K (33° C - 43° C). The governor and fuel system shall be adjusted as established by the manufacturer's sales and service literature. The following steps shall be taken for each test:

4.2.1. instrumentation and sample probes shall be installed as required;

4.2.2. the cooling system shall be started;

4.2.3. the engine shall be started and warmed up until all temperatures and pressures have reached equilibrium;

4.2.4. the torque curve at full load shall be determined by experimentation to calculate the torque values for the specified test modes; the maximum permissible power absorbed by engine-driven equipment, declared by the manufacturer to be applicable to the engine type, shall be taken into account. The dynamometer setting for each engine speed and load shall be calculated using the formula;

$$s = P_{min} \cdot \frac{L}{100} + P_{aux}$$

where

s dynamometer setting.

P_{min} minimum net engine power as indicated in line (e) in the table of paragraph 7.2 of annex 1.

L per cent load as indicated in paragraph 4 of this annex.

P_{aux} total permissible power absorbed by engine driven equipment minus the power of any such equipment actually driven by the engine: (d)-(b) of annex 1, paragraph 7.2;

4.2.5. the emission analysers shall be set at zero and spanned;

4.2.6. the test sequence shall be started (see paragraph 4.1 of this annex). The engine shall be operated for six minutes in each mode, completing engine speed and load changes in the first minute. The responses of the analysers shall be recorded for the full six minutes with exhaust gas flowing through the analysers at least during the last three minutes. The engine speed and load, intake air temperature and depression, exhaust temperature and back pressure, fuel flow and air or exhaust flow shall be recorded during the last five minutes of each mode, with the speed and load requirements being met during the last minute of each mode;

4.2.7. any additional data required for calculation shall be read and recorded (see paragraph 5 of this annex).

4.2.8. the zero and span settings of the emission analysers shall be checked and reset, as required, at least at the end of the test. The test shall be considered satisfactory if the adjustment necessary after the test does not exceed the accuracy of the analysers prescribed in paragraph 2.3.2 of appendix 1 to this annex.

5. Data evaluation

The last 60 seconds of each mode shall be located, and the average chart reading for HC, CO and NO_x during each mode shall be determined from the average chart readings and the corresponding calibration data. However, a different type of registration can be used if it ensures an equivalent data acquisition.

Annex 4 - Appendix 1

MEASUREMENT AND SAMPLING PROCEDURES

1. Introduction

The gaseous emissions from the exhaust of the engine include hydrocarbons, carbon monoxide and oxides of nitrogen. During a prescribed sequence of warmed up engine operating conditions the amounts of the above gases in the exhaust shall be examined continuously. The prescribed sequence of operations consist of a number of speed and power modes which span the typical operating range of C.I. engines. During each mode the concentration of each pollutant, exhaust flow and power output shall be determined and the measured values weighted and used to calculate the grams of each pollutant emitted per kilowatt hour (g/kWh) as described in this annex.

2. Equipment

2.1. Dynamometer and engine equipment

The following equipment shall be used for emission tests of engines on engine dynamometers:

2.1.1. an engine dynamometer with adequate characteristics to perform the test cycle described in paragraph 4 of this annex.

2.1.2. measuring instruments for speed, torque, fuel consumption, air consumption or exhaust gas flow, temperature of coolant and lubricant, exhaust gas pressure and inlet manifold depression, exhaust gas temperature, air inlet temperature, atmospheric pressure, humidity and fuel temperature. The accuracy of these instruments shall satisfy, where appropriate, the ECE method of measuring the power of the internal combustion engines of road vehicles; other instruments shall have an accuracy which satisfies the following requirements.

2.1.2.1. Temperatures.

Temperatures shall be measured with an accuracy of ± 1.5° C.

2.1.2.2. Absolute humidity.

The absolute humidity (H) shall be determined to an accuracy of ± 5%.

2.1.3. an engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures for the duration of the prescribed engine tests;

2.1.4. a non-insulated and uncooled exhaust system extending at least 0.5 m past the point where the exhaust probe is located. The pressure measured at the exit of the engine exhaust system shall not differ by more than 1 kPa from that specified in point 1.18 of annex 1. The exit from the engine exhaust system is defined as a point 150 mm downstream from the termination of the part of the exhaust system mounted on the engine;

2.1.5. an engine air inlet system presenting an air inlet depression which shall not differ by more than 0.3 kPa from that specified in paragraph 1.17 of annex 1.

2.2. Exhaust gas flow

For calculation of the emission it is necessary to know the exhaust gas flow (see paragraph 1.1 of appendix 3 of this annex). For determination of exhaust flow either of the following methods may be used:

(a) Direct measurement of the exhaust flow by flow nozzle or equivalent metering system.

(b) Measurement of the air flow and the fuel flow by suitable metering systems and calculation of the exhaust flow by the following equations:

$$G''_{EXH} = G''_{AIR} + G_{FUEL} \quad \text{(wet exhaust mass)}$$

or $$V'_{EXH} = V''_{AIR} - 0.75\ G_{FUEL} \quad \text{(dry exhaust volume)}$$

or $$V''_{EXH} = V''_{AIR} + 0.77\ G_{FUEL} \quad \text{(wet exhaust volume)}$$

The accuracy of exhaust flow determination shall be ± 2.5% or better. The concentration of carbon monoxide is measured in the dry exhaust. For this reason the CO emissions shall be calculated using the dry exhaust gas volume V'_{EXH}. The NO_x emissions shall be calculated using the wet exhaust gas volume V''_{EXH}. If the exhaust mass flow rate (G''_{EXH}) is used in the calculation, the CO and NO_x concentrations shall be related to the wet exhaust. Calculation of the HC emission shall include G''_{EXH} and V''_{EXH} according to the measuring method used.

2.3. Analytical and sampling equipment

Appendix 4 of this annex describes the analytical system in current use. Other systems or analysers which have proved to give equivalent results may be used.

2.3.1. Analysers

Pollutant gases shall be analysed with the following instruments:

2.3.1.1. Carbon Monoxide (CO) analysis

The carbon monoxide analyser shall be of the non-dispersive INFRARED (NDIR) absorption type.

2.3.1.2. Hydrocarbons (HC) analysis

The hydrocarbon analyser shall be of the HEATED FLAME IONIZATION (HFID) type with Detector, Valves, Pipework, etc. heated so as to maintain a gas temperature of 453 K - 473 K (180° C - 200° C). It shall be calibrated in accordance with paragraph 4.5.2 of appendix 2 to this annex.

2.3.1.3. Oxides of nitrogen (NO_x) analysis.

The nitrogen oxide analyser shall be of the HEATED CHEMILUMINESCENT (HCLA) type with an NO_2-NO converter.

2.3.2. Accuracy

The analysers shall have a measuring range compatible with the accuracy required to measure the concentrations of the exhaust gas sample pollutants. Measurement error shall not exceed ± 3%. For concentrations of less than 100 ppm the measurement error shall not exceed ± 3 ppm.

2.3.3. Gas drying

Optional gas drying devices shall have no effect on the pollutant content of the gas stream.

2.3.4. Sampling

A heated sample line for continuous HC analysis with the flame ionization detector (HFID), including recorder (R) is to be used. Throughout the test, the temperature of the complete sampling system shall be maintained at a temperature of 453 K - 473 K (180° C - 200° C). The heated sampling line shall be fitted with a heated filter (F) (99% efficient with particles $\geq$ 0.3 µm) to extract any solid particles from the continuous flow of gas required for analysis. A second heated sample line for NO_x analysis is to be used. The temperature of this line shall be controlled at 368 K - 473 K (95° C - 200° C). The sample line for CO (CO_2) analysis may be heated or unheated.

Annex 4 - Appendix 2

CALIBRATION PROCEDURE

1. Introduction

Each analyser shall be calibrated as often as necessary to fulfil the accuracy requirements of this annex. The calibration method that shall be used is described in this appendix for the analysers indicated in paragraph 2.3 of appendix 1 to this annex.

2. Gases

2.1. Pure Gases

The following gases must be available if necessary for operation.

Purified Nitrogen:	Purity $\leq$ 1 ppm C; $\leq$ 1 ppm CO; $\leq$ 400 ppm CO_2; $\leq$ 0.1 ppm NO
Purified Oxygen:	Purity $\geq$ 99.5% vol. O_2
Hydrogen mixture:	40 $\pm$ 2% hydrogen, balance nitrogen or helium. Purity $\leq$ 1 ppm C; $\leq$ 400 ppm CO
Purified synthetic air:	Purity $\leq$ 1 ppm C; $\leq$ 1 ppm CO: $\leq$ 400 ppm CO_2; $\leq$ 0.1 ppm NO Oxygen content between 18 and 21% vol.

2.2. Calibration and Span Gases

Gases having the following chemical compositions shall be available:

Mixtures of:

C_3H_8 and purified synthetic air (see paragraph 2.1 above);

CO and purified nitrogen;

NO and purified nitrogen (the amount of NO_2 contained in this calibration gas must not exceed 5% of the NO content);

The true concentration of a calibration and span gas must be within $\pm$ 2% of the nominal value. All concentrations of calibration gas shall be given on a volume basis (volume % or volume ppm).

The gases used for calibration and span may also be obtained by means of a gas divider, diluting with purified nitrogen or with purified synthetic air. The accuracy of the mixing device must be such that the concentrations of the diluted calibration and span gases may be determined to within ± 2%.

3. Operating procedure for analysers and sampling system

The operating procedure for analysers shall follow the start-up and operating instructions of the instrument manufacturer. The following minimum requirement shall be included.

4. Calibration procedure

4.1. The instrument assembly shall be calibrated and calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust.

4.1.1. A minimum of two hours shall be allowed for warming up the analysers.

4.1.2. A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilization period all flow meters and pressure gauges should read zero. If not, the sampling line(s) shall be checked and the fault corrected.

4.1.3. The NDIR analyser shall be tuned, where appropriate, and the flame combustion of the HFID analyser optimized.

4.1.4. Using purified synthetic air (or nitrogen), the CO, NO_x and HC analysers shall be set at zero. Using appropriate calibrating gases, the analysers shall be recalibrated as in paragraph 4.2 below.

4.1.5. The zero setting shall be rechecked and the procedure described in paragraph 4.1.4 above repeated, if necessary.

4.2. Establishment of the Calibration Curve

4.2.1. Each normally used operating range is calibrated in accordance with the following procedure.

4.2.2. The analyser calibration curve is established by at least five calibration points spaced as uniformly as possible. The nominal concentration of the calibration gas of the highest concentration must be not less than 80% of the full scale.

4.2.3. The calibration curve is calculated by the method of least squares. If the resulting polynomial degree is greater than 3, the number of calibration points must be at least equal to this polynomial degree plus 2.

4.2.4. The calibration curve must not differ by more than 2%, from the nominal value of each calibration gas.

4.2.5. Trace of the calibration curve.

From the trace of the calibration curve and the calibration points, it is possible to verify that the calibration has been carried out correctly. The different characteristic parameters of the analyser must be indicated, particularly:

the scale
the sensitivity
the zero point
the date of carrying out the calibration

4.2.6. If it can be shown to the satisfaction of the technical service that alternative technology (e.g. computer, electronically controlled range switch, etc.) can give equivalent accuracy, then these alternatives may be used.

4.3. Verification of the Calibration

4.3.1. Each normally used operating range shall be checked prior to each analysis in accordance with the following:

4.3.2. The calibration is checked by using a zero gas and a span gas whose nominal value is near to the supposed value to be analysed.

4.3.3. If, for the two points considered, the value found does not differ by more than ± 5% of the full scale from the theoretical value, the adjustment parameters may be modified. Should this not be the case, a new calibration curve shall be established in accordance with paragraph 4.2 of this appendix.

4.3.4. After testing, zero gas and the same span gas will be used for rechecking. The analysis will be considered acceptable if the difference between the two measuring results is less than 2%.

4.4. Efficiency test of the NO_x Converter

4.4.1. The efficiency of the converter used for the conversion of NO_2 into NO is tested as follows:

4.4.2. Using the test set up as shown at the end of this annex and the procedure below, the efficiency of converters can be tested by means of an ozonator.

4.4.3. Calibrate the chemiluminescent analyser (CLA) in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which must amount to about 80%

of the operating range and the NO_2 concentration of the gas mixture to less than 5% of the NO concentration). The NO_x analyser must be in the NO mode so that the span gas does not pass through the converter. Record the indicated concentration.

4.4.4. Via a T fitting, oxygen is added continuously to the gas flow until the concentration indicated is about 10% less than the indicated calibration concentration given in paragraph 4.4.3.

Record the indicated concentration (c). The ozonator is kept deactivated throughout the process.

4.4.5. The ozonator is now activated to generate enough ozone to bring the NO concentration down to 20% (minimum 10%) of the calibration concentration given in paragraph 4.4.3. Record the indicated concentration (d).

4.4.6. The NO analyser is then switched to the NO_x mode which means that the gas mixture (consisting of NO, NO_2, O_2 and N_2) now passes through the converter. Record the indicated concentration (a).

4.4.7. The ozonator is now deactivated. The mixture of gases described in paragraph 4.4.4 passes thorugh the converter into the detector. Record the indicated concentration (b).

4.4.8. With the ozonator deactivated, the flow of oxygen or synthetic air is also shut off. The NO_x reading of the analyser must then be no more than 5% above the figure given in paragraph 4.4.3.

4.4.9. The efficiency of the NO_x converter is calculated as follows:

$$\text{Efficiency } (\%) = \left(1 + \frac{a - b}{c - d}\right) \cdot 100$$

4.4.10. The efficiency of the converter must be tested prior to each calibration of the NO_x analyser.

4.4.11. The efficiency of the converter must not be less than 95%.

NOTE: If the analyser operating range is above the highest range that the NO_x generator can operate to give a reduction from 80 to 20%, then the highest range the NO_x generator will operate on will be used.

4.5. Checking for FID hydrocarbon response

4.5.1. Detector response optimization.

The FID must be adjusted, as specified by the instrument manufacturer. Propane in air should be used, to optimize the response, on the most common operating range.

4.5.2. Calibration of the HC analyser.

The analyser should be calibrated using propane in air and purified synthetic air. See paragraph 2.2 of this appendix (calibration and span gases).

Establish a calibration curve as described in paragraphs 4.2 to 4.3.4 of this appendix.

4.5.3. Response factors of different hydrocarbons and recommended limits.

The response factor (Rf), for a particular hydrocarbon species is the ratio of the FID C1 reading to the gas cylinder concentration, expressed as ppm C1.

The concentration of the test gas must be at a level to give a response of approximately 80% of full scale deflection, for the operating range. The concentration must be known, to an accuracy of ± 2% in reference to a gravimetric standard expressed in volume. In addition the gas cylinder must be pre-conditioned for 24 hours at a temperature between 20° C and 30° C.

Response factors should be determined when introducing an analyser into service and thereafter at major service intervals. The test gases to be used and the recommended response factors are:

Methane and purified air	$1.00 \leq Rf \leq 1.15$
Propylene and purified air	$0.90 \leq Rf \leq 1.00$
Toluene and purified air	$0.90 \leq Rf \leq 1.00$

Relative to a response factor (Rf) of 1.00 for propane and purified air.

4.5.4. Oxygen interference check and recommended limits.

The response factor should be determined as described in paragraph 4.5.3 above. The test gas to be used and recommended response factor range are:

Propane and nitrogen	$0.95 \leq Rf \leq 1.05$

Annex 4 - Appendix 3

CALCULATION OF GASEOUS EMISSIONS

1. Calculation

1.1. The final reported test results shall be derived through the following steps:

1.1.1. The exhaust gas mass flow rate G''_{EXH} and V''_{EXH} shall be determined (see paragraph 2.2 of appendix 1) for each mode:

1.1.2. When applying G_{EXH} the measured carbon monoxide concentration shall be converted to a wet basis according to paragraph 1.1.2.1 below, if not already measured on a wet basis.

1.1.2.1. CO exhaust gas concentration measured on a dry basis is to be converted to a wet basis. To convert the measured values to the concentrations present in the exhaust (wet basis), the following relationship may be employed:

$$\text{- ppm (wet basis)} = \text{ppm (dry basis)} \cdot \left(1 - 1.85 \frac{G_{FUEL}}{G_{AIR}}\right)$$

where:

G_{FUEL} is the fuel flow (kg/s) (kg/h)

G_{AIR} is the air flow (kg/s) (kg/h) (dry air)

1.1.3. The NO_x concentration shall be corrected for humidity according to paragraph 1.1.3.1 below.

1.1.3.1. The values of the oxides of nitrogen shall be multiplied by the following humidity correction factor.

$$\frac{1}{1 + A\,(7H-75) + B \cdot 1.8\,(T-302)}$$

where:

$$A = 0.044 \frac{G_{FUEL}}{G_{AIR}} - 0.0038$$

$$B = -0.116 \frac{G_{FUEL}}{G_{AIR}} + 0.0053$$

T = temperature of the air in K

$\frac{G_{FUEL}}{G_{AIR}}$ = Fuel air ratio (dry air basis)

H = humidity of the inlet air in grammes of H_2O per kilogramme of dry air

in which:

$$H = \frac{6.211 \cdot R_a \cdot P_d}{P_B - P_d \cdot R_a \cdot 10^{-2}}$$

where:

R_a = Relative humidity of the ambient air expressed in %

P_d = Saturation vapour pressure at ambient temperature expressed in kPa

P_B = Atmospheric pressure expressed in kPa

1.1.4. The pollutant mass flow for each mode shall be calculated as follows:

(1) NO_x mass = 0.001587 x NO_x conc x G''_{EXH}

(2) CO_{mass} = 0.000966 x CO conc x G''_{EXH}

(3) HC_{mass} = 0.000478 x HC conc x G''_{EXH}

or:

(1) NO_x mass = 0.00205 x NO_x conc x V''_{EXH} (wet)

(2) CO_{mass} = 0.00125 x CO conc x V'_{EXH} (dry)

(3) HC_{mass} = 0.000618 x HC conc x V''_{EXH} (wet)

(4) NO_x mass = 0.00205 x NO_x conc x V'_{EXH} (dry) 1/

1/ For NO_x analysers according to paragraph 2.3.3 of appendix 1 to this annex.

1.1.5. The emissions shall be calculated in the following way:

$$NO_x = \frac{\sum NO_x \text{ mass} \cdot WF}{\sum P \cdot WF}$$

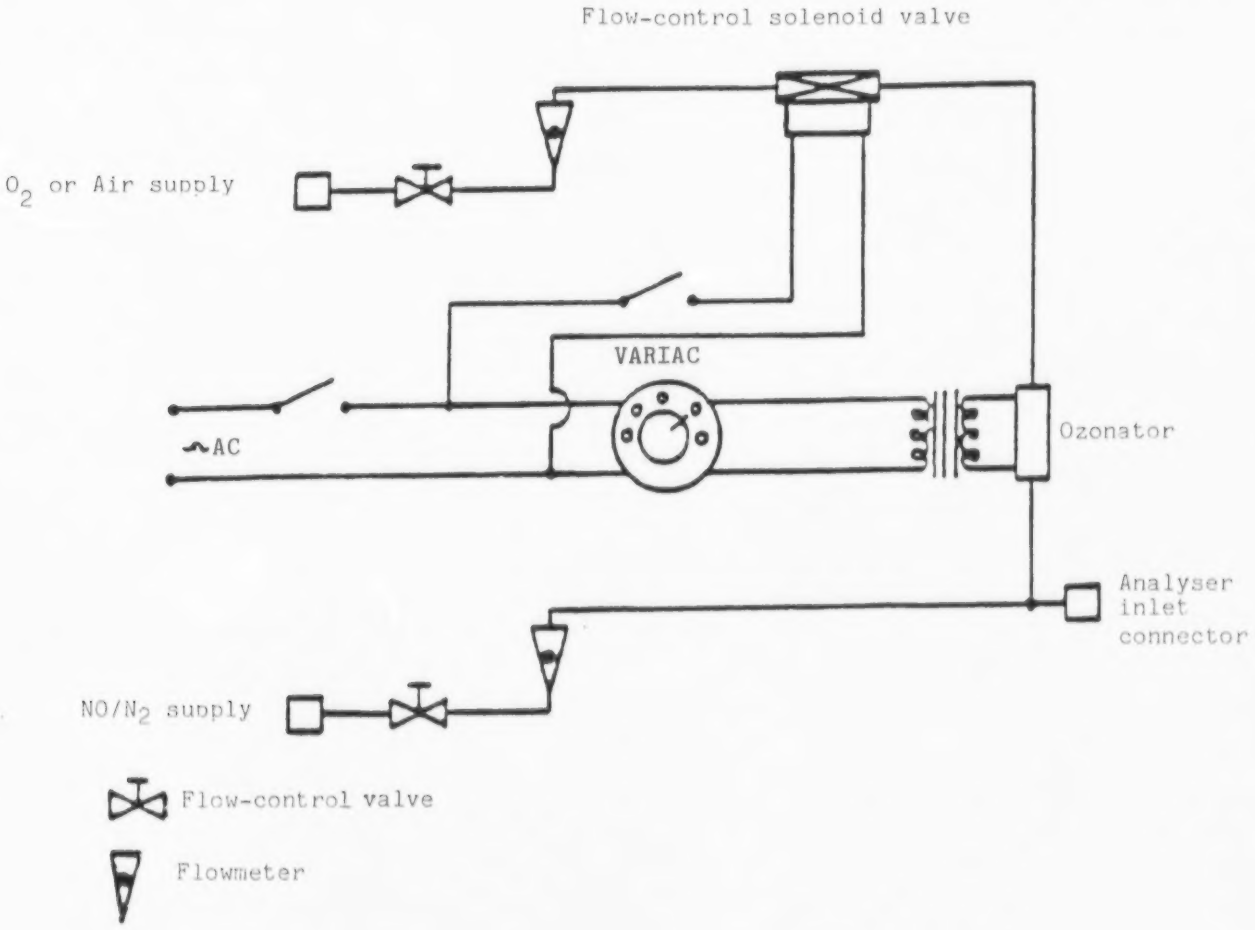
$$CO = \frac{\sum CO_{mass} \cdot WF}{\sum P \cdot WF}$$

$$HC = \frac{\sum HC_{mass} \cdot WF}{\sum P \cdot WF}$$

The weighting factors used in the above calculation are according to the following table:

Mode No.	WF
1	0.25/3
2	0.08
3	0.08
4	0.08
5	0.08
6	0.25
7	0.25/3
8	0.10
9	0.02
10	0.02
11	0.02
12	0.02
13	0.25/3

Schematic of NO_x converter efficiency device



Annex 4 - Appendix 4

ANALYTICAL SYSTEM

A schematic diagram of the analytical and sampling system using HCLA or equivalent systems for measuring NO_x is shown in Figure 1 of this appendix.

SP - Stainless steel sample probe to obtain samples from exhaust system. A closed end, multi-hole straight probe extending at least 80% across the exhaust pipe is recommended. The exhaust gas temperature at the probe shall be not less than 343 K (70° C).

HSL1 - Heated sampling line, temperature shall be kept at 453 K - 473 K (180° C - 200° C): the line shall be made in stainless steel of PTFE.

F1 - Heated pre-filter, if used; temperature shall be the same as HSL1.

T1 - Temperature readout of sample streams entering oven compartment.

V1 - Suitable valving for selecting sample, span gas or air or gas flow to the system. The valve shall be in the oven compartment or heated to the temperature of the sampling line HSL1.

V2,V3 - Needle valves to regulate calibration gas and zero gas.

F2 - Filter to remove particulates. A 70 mm diameter glass fibre type filter disc is suitable. The filter shall be readily accessible and changed daily or more frequently, as needed.

P1 - Heated sample pump

G1 - Pressure gauge to measure pressure in sample line HC-analyser.

R3 - Pressure regulator valve to control pressure in sample line and flow to detector.

HFID - Heated flame ionization detector for hydrocarbons. Temperature of oven shall be kept at 453 K - 473 K (180° C - 200° C).

FL1,FL2,FL3 - Flow meter to measure sample by-pass flow.

R1,R2 - Pressure regulators for air and fuel.

HSL2 - Heated sampling line, temperature shall be kept between 368 K - 473 K (95° C - 200° C); the line shall be made in stainless steel or PTFE.

HCLA - Heated chemiluminescence analyser for oxides of nitrogen.

T2 - Temperature readout of sample stream entering HCLA analyser.

T3 - Temperature readout of NO_2 - NO converter.

V9,V10 - Three-way valve to by-pass NO_2 - NO converter.

V11 - Needle valve to balance flow through NO_2 - NO converter and by-pass.

SL - Sample line. The line shall be made in PTFE or in stainless steel. It may be heated or unheated.

B - Bath to cool and condense water from exhaust sample. The bath shall be maintained at a temperature of 273 K - 277 K (0° C - 4° C) by ice or refrigeration.

C - Cooling coil and trap sufficient to condense and collect water vapour (optional with water insensitive analyser).

T4 - Temperature readout of bath temperature.

V5,V6 - Toggle valves to drain condensate traps and bath.

R4,R5 - Pressure regulator to control sample flow.

V7,V8 - Ball valve or solenoid valves to direct sample, zero gas or calibrating gas streams to the analysers.

V12,V13 - Needle valves to regulate flows to the analysers.

CO - NDIR analyser for carbon monoxide.

NO_x - HCLA analyser for oxides of nitrogen.

FL4,FL5 - By-pass flowmeter.

V4,V14 - Three-way ball or solenoid valves. The valves shall be in an oven compartment or heated to the temperatures of the sampling line HSL1.

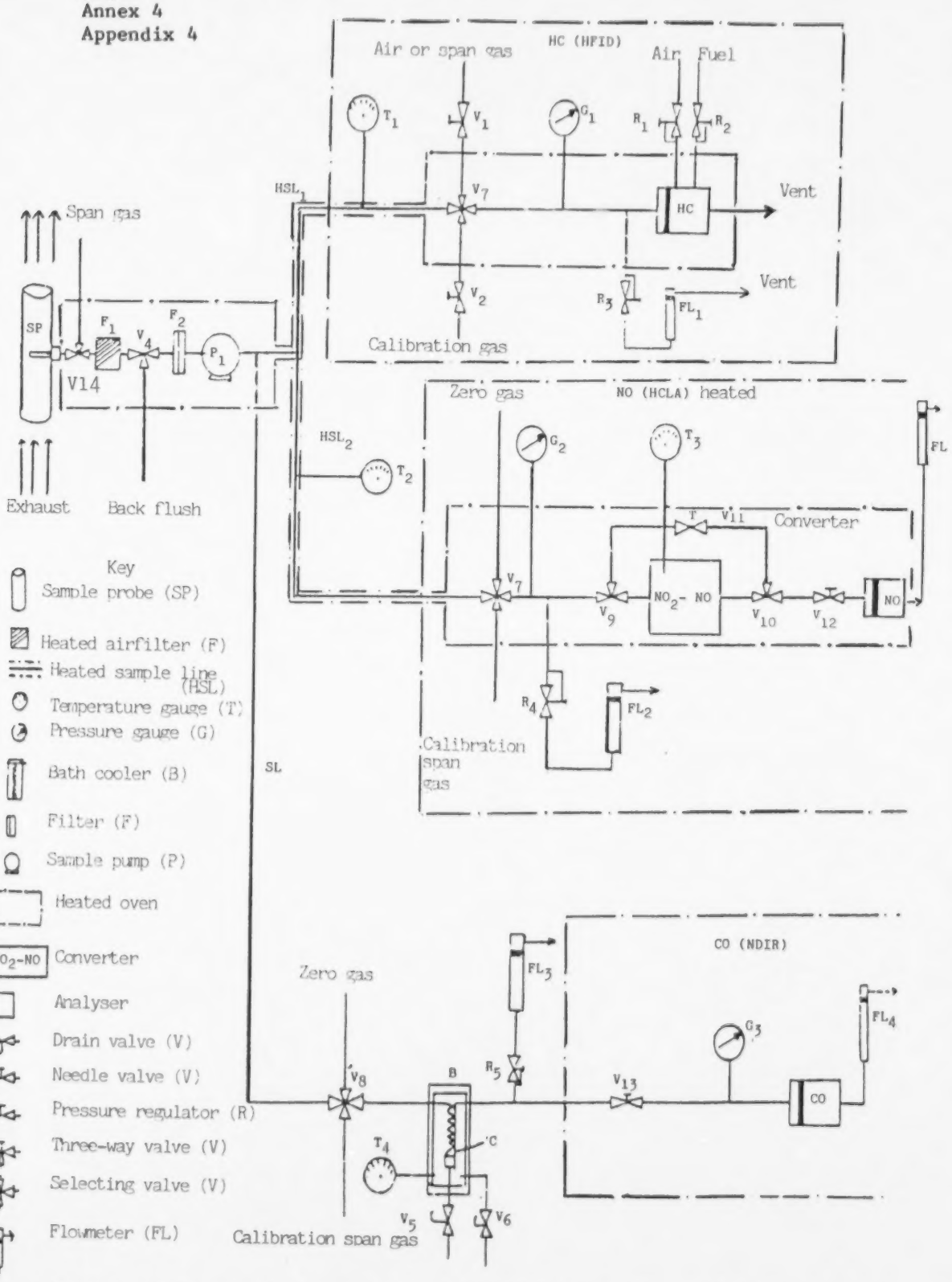


Figure 1. Flow diagram of exhaust gas analysis system for CO_1 NO_x and HC (analysis by HCLA and heated sample line).

Annex 5

TECHNICAL CHARACTERISTICS OF REFERENCE FUEL PRESCRIBED FOR APPROVAL TESTS AND TO VERIFY CONFORMITY OF PRODUCTION

CEC reference fuel RF-03-A-84 (1) (3) (7)

Type: Diesel Fuel

	Limits and Units	ASTM Method
Cetane Number (4)	min. 49 max. 53	D 613
Density 15° C (Kg/1)	min. 0.835 max. 0.845	D 1298
Distillation (2) 50% 90% FBP	min. 245° C min. 320° C max. 340° C max. 370° C	D 86
Flash Point	min. 55° C	D 93
CFPP	min. - max. - 5° C	EN 116 (CEN)
Viscosity 40° C	min. 2.5 mm^2/S max. 3.5 mm^2/S	D 445
Sulphur content	(to be reported) max. 0.3% mass	D 1266/D 2622 D 2785
Copper corrosion	max. 1	D 130
Conradson carbon residue (10% DR)	max. 0.2% mass	D 189
Ash content	max. 0.01% mass	D 482
Water content	max. 0.05% mass	D 95/D 1744
Neutralization (strong acid) number	max. 0.2 mg KOH/g	
Oxidation stability (6)	max. 2.5 mg/100m	D 2274
Additives (5)		
Carbon-Hydrogen ratio	(to be reported)	

Note 1: Equivalent ISO methods will be adopted when issued for all properties listed above.

Note 2: The figures quoted show the evaporated quantities (percentage recovered + percentage loss).

Note 3: The values quoted in the specification are "true values". In establishment of their limit values the terms of ASTM D 3244 "Defining a basis for petroleum produce quality disputes" have been applied and in fixing a minimum value, a minimum difference of 2R above zero has been taken into account; in fixing a maximum and minimum value, the minimum difference is 4R (R = reproducibility).

Notwithstanding this measure, which is necessary for statistical reasons, the manufacturer of fuel should nevertheless aim at a zero value where the stipulated maximum value is 2R and at the mean value in the case of quotations of maximum and minimum limits. Should it be necessary to clarify the question as to whether a fuel meets the requirements of the specification, the terms of ASTM D 3244 should be applied.

Note 4: The range of cetane is not in accordance with the requirement of a minimum range of 4R. However, in cases of dispute between fuel supplier and fuel user, the terms in ASTM D 3244 can be used to resolve such disputes provided replicate measurements, of sufficient number to achieve the necessary precision, are made in preference to single determinations.

Note 5: This fuel should be based straight run and cracked hydrocarbon distillate components only; desulphurization is allowed. It must not contain any metallic additives or cetane improver additives.

Note 6: Even though oxidation stability is controlled, it is likely that shelf life will be limited. Advice should be sought from the supplier as to storage conditions and life.

Note 7: If it is required to calculate thermal efficiency of an engine or vehicle, the calorific value of the fuel can be calculated from:

Specific energy (calorific value) (net) MJ/kg =

$$(46.423 - 8.792d^2 + 3.17d)(1 - (x + y + s)) + 9.42s - 2.499x$$

where:

d is the density at 15° C
x is the proportion by mass of water (%/100)
y is the proportion by mass of ash (%/100)
s is the proportion by mass of sulphur (%/100).

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